



# DESIGN COMPACT MULTI FREQUENCY FOLDED U-SLOT ANTENNA WITH SQUARE SLOT & VIA HOLE TECHNIQUE

Ujjaya Rai<sup>1</sup> | Rahul Dubey<sup>2</sup>

<sup>1</sup> PG Scholar's, OIST Bhopal

<sup>2</sup> Asso Prof, OIST Bhopal

## ABSTRACT

A multi frequency Folded U-Slot microstrip antenna is design and validated in this paper. The proposed antenna consists of folded u-slot, square slot, with via hole technique, the results of all technique is shown in each section step wise, this technique enhance return losses for all three frequency 2.5GHz, 4.8GHz and 7GHz return losses are -17.5dB, -28dB, -27dB, respectively and gives compactness of 50% at frequency of 2.5GHz, The resonant frequencies of the proposed antenna are determined by transmission line model. The physical size parameters of proposed design is calculated using transmission line model, the multi frequency capability is obtained by adjusting the parameters of the proposed structure. The proposed antenna operates at 2.5, 4.8, and 7 GHz, respectively. The multi frequency capability useful in applications of Bluetooth, satellite communication. WLAN, Wi-Max.

**KEY WORDS:** Multi frequency, folded U-Slot, Via hole technique.

## I. INTRODUCTION

In rapid development of wireless communication and recent technology in order to satisfy various demands for wireless services, antenna miniaturization and multi frequency technologies have been an useful in Bluetooth ,WLAN satellite communication ,Wi-Max, and challenging, and pressing issue for scientists and researchers in communication industry. Electromagnetic (EM) metamaterials (MTMs), especially for transmission line (TL), have intrigued a great impetus and renewed interest in the compact and multiband antenna design, e.g., resonant antennas based on single negative TL [1], [2], and compact multi frequency antennas using composite right- and left-handed (CRLH) TL [3]–[11]. With a zero propagation constant inherent in the left-handed (LH) MTM, the operating frequency of resonant antennas using CRLH TL is independent of the size. Hence, a compact antenna can be designed with the property of zero propagation constant, among which the most important part is the zeroth-order resonance (ZOR) antennas using mushroom structures [7]–[11]. This is especially in [8], where a combination of right-handed (RH) patches and mushroom structure is applied to design the ZOR antenna achieving the frequency ratio tunable, the miniaturization, and dual-band at the same time. However, it is impossible to modulate the frequency by changing the dimension of RH section and the mushroom part independently for the interaction between them, and also the miniaturization of a conventional mushroom structure is insufficient, which requires a more compact and convenience structure to realize frequency modulation. The presence and role of slots in the ground plane and in patches are discussed for example in [12]–[14]. In [12], the slots in the patch have been introduced to generate multiband resonator, while in [14] they are used for biasing purpose. In [13], slots in the ground plane are used for the realization of an appropriate feeding network. Their effect on the dispersion diagram is further analyzed. Also, a survey of literature suggests that folded U-Slot is a good choice for compactness. Compactness and antenna operate in multiple frequency of application is needed in communication.

## II. PROPOSED DESIGN

The proposed antenna designs at central frequency of 5GHz, by using FR-4 material, the FR-4 material have dielectric constant of 4.4, height of 1.5mm and loss tangent .02. transmission line model used for designing of proposed design, in this work design five antenna to conclude final geometry, firstly design theoretical antenna at 5GHz, Folded u-slot technique used to gives dual band at two frequency, folded u- slot antenna is design by using the technique of impedance matching, by using stub matching method firstly find out length and position of the slot. The distance between two slots considers  $\lambda/2$ . Via hole technique used to generate compactness of antenna, via hole technique enhance surface current, and reduce the reflection of geometry, the dimension of antenna calculated using transmission line model , transmission line model discuss in following steps

**Step 1:** Calculation of the Width (W):

$$W = \frac{c}{2 f_0 \sqrt{\frac{\epsilon_r + 1}{2}}}$$

$$W = 22\text{mm}$$

**Step 2:** Calculation of Effective dielectric constant ( $\epsilon_{\text{eff}}$ ):

$$\epsilon_{\text{eff}} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[ 1 + 12 \frac{h}{w} \right]^{-\frac{1}{2}}$$

**Step 3:** Calculation of the length extension ( $\Delta L$ ):

$$\Delta L = \frac{0.412h(\epsilon_{\text{eff}} + 0.3) \left( \frac{w}{h} + 0.264 \right)}{(\epsilon_{\text{eff}} - 0.258) \left( \frac{w}{h} + 0.8 \right)}$$

**Step 4:** Calculation of the Effective length ( $L_{\text{eff}}$ ):

$$L_{\text{eff}} = \frac{c}{2 f_0 \sqrt{\epsilon_{\text{eff}}}}$$

Substituting  $c = 3.00 \times 10^8$  m/s and  $f = 5$  GHz,

**Step 5:** Calculation of actual length of patch (L):  $L = L_{\text{eff}} - 2\Delta L$   
 $L = 17.77$

The dimension of ground plan is

$$L_g = L + 6h$$

$$W_g = W + 6h$$

## III. DESIGN ANALYSIS

### A. Theoretical Design

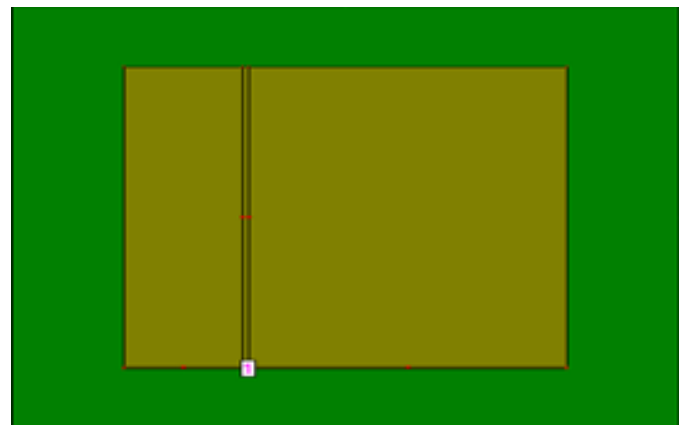


Fig 1 Theoretical Design

In the theoretical design shown in fig 1, designing at the center frequency of 5GHz by the use of transmission line model, the return losses of proposed design is shown in figure 2

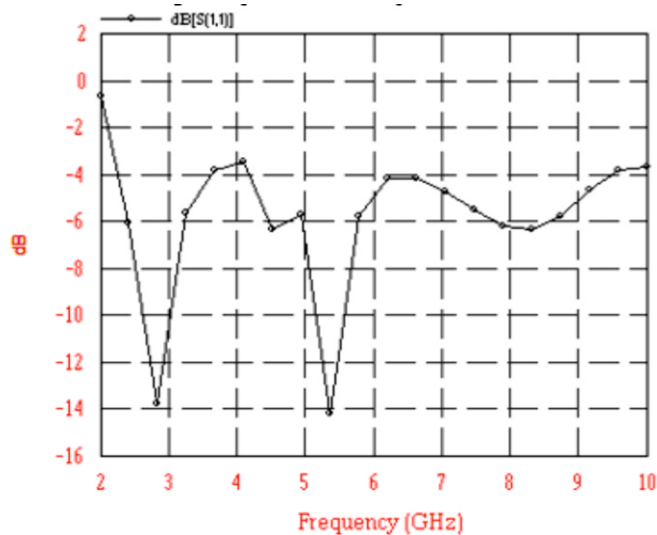


Figure 2 Return losses Vs Frequency

In fig 2, obtain return losses  $S_{11} \leq -10\text{dB}$ , at frequency 2.9GHz and 5.4GHz, to improved return losses of geometry used single U-Slot in the patch of geometry shown in fig 3. U-Slot design using stub matching method by smith chart.

#### B. Design with single U-Slot

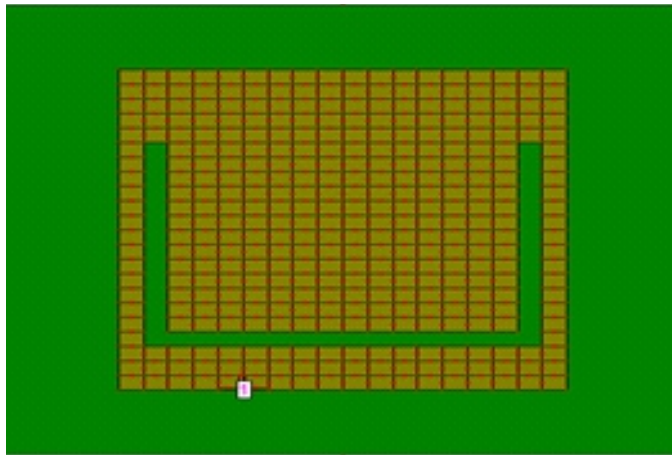


Figure 3 Proposed antenna with single U-Slot

For designing of Single U-Slot using stub matching method, in strip type of antenna preferred open circuit stub design in form of slot cut in design, length of the slot  $L_s$  and position of the slot find out by the used of smith chart as per theory of stub matching, the width of the slot  $W_s$  find out by

$$f_o = \frac{c}{2(L_s + W_s)}$$

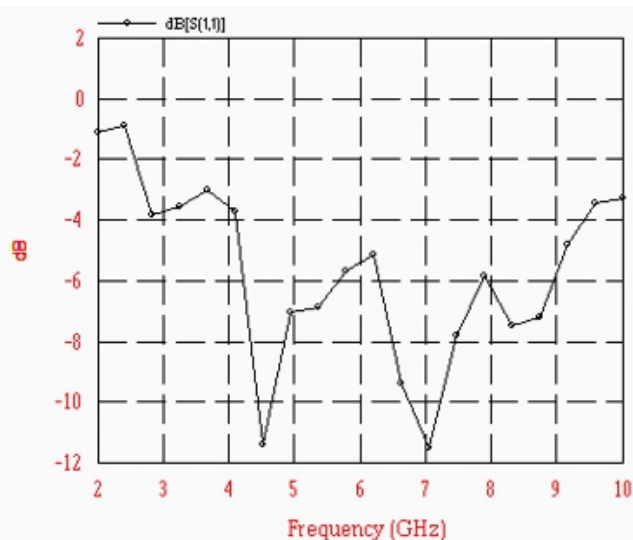


Figure 4 Return losses Vs Frequency

For improving return loss of geometry in next section used via hole technique.

#### C. Design with single U-Slot with shorting via hole

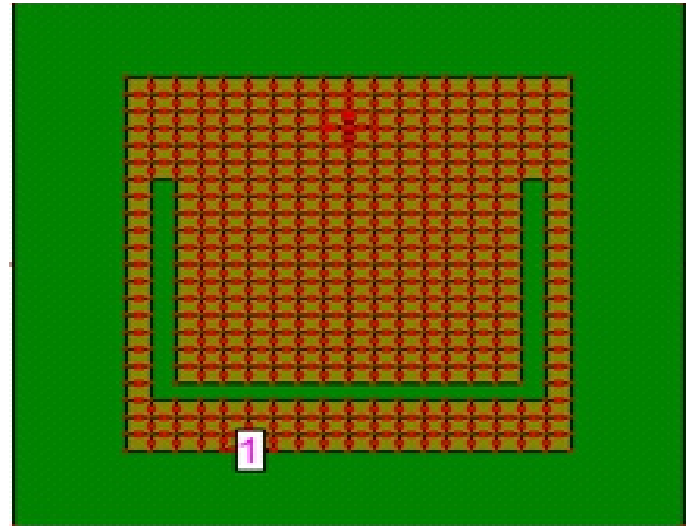


Figure 5 Proposed antenna with single U-Slot and via hole technique

The via hole technique used in proposed geometry is shown in fig 5, via hole technique optimized the inductance of proposed design and improve surface current and reduce reflection of geometry because of this overall return loss of geometry is improved and obtain return loss up to -33dB,

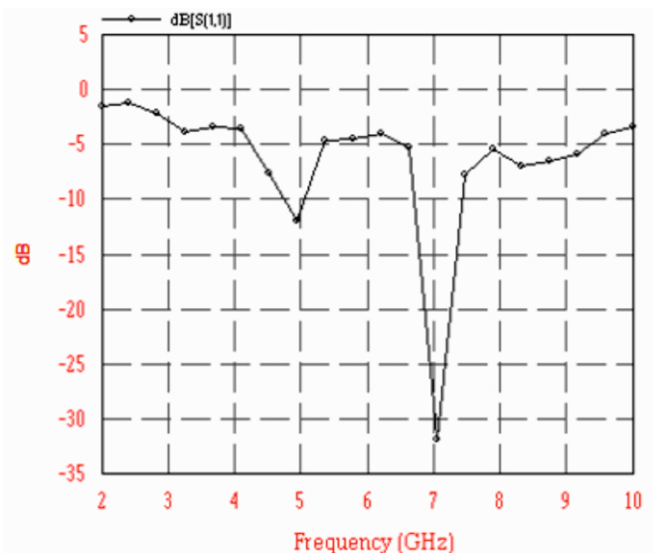


Figure 6 Return losses Vs Frequency

Return loss of geometry is shown in fig 6, return losses is -33dB, at 7GHz, to generate multiple frequency of application of design used square slot in proposed in geometry.

#### D. Design with single U-Slot square slot with via hole technique

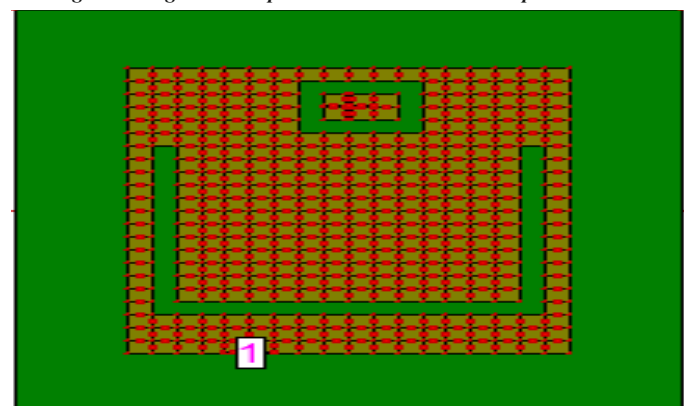


Figure 7 Proposed antenna with single U-Slot square slot with via hole technique

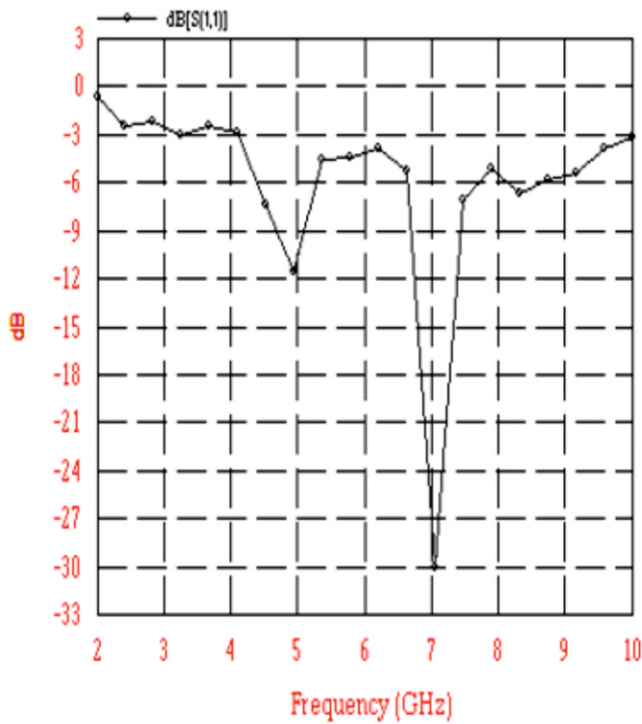


Figure 10 Return losses Vs Frequency

Validation of all proposed antenna is shown in table-1, with respect to used frequency and respectively return loss.

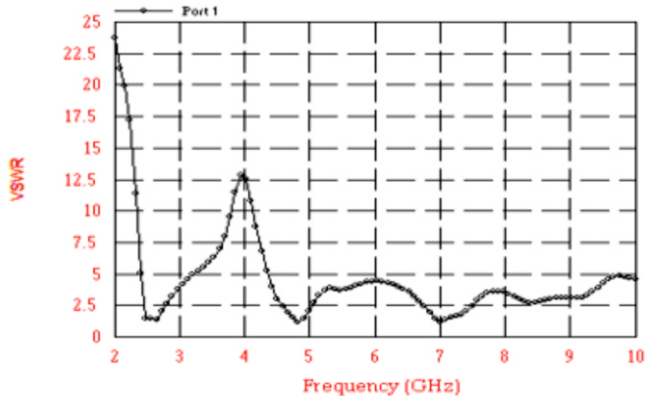


Figure 11 VSWR Vs Frequency

The VSWR of proposed design is shown in figure 11. At resonance frequency 4.8GHz VSWR is 1.085, at frequency 2.5GHz VSWR is 1.3 and resonance frequency 7GHz VSWR is 1.097.

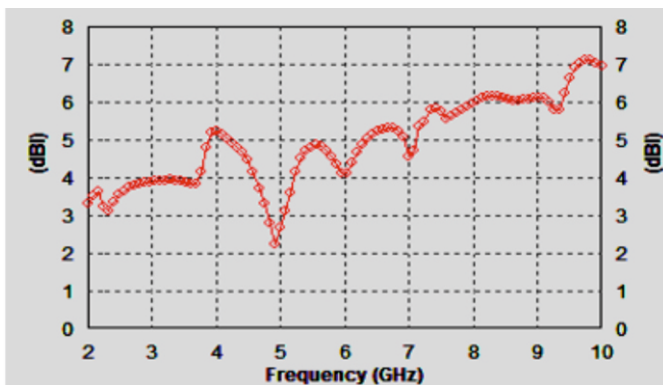


Figure 12 Directivity Vs Frequency

The directivity proposed design is shown in fig 12, directivity achieved up to 5dBi,

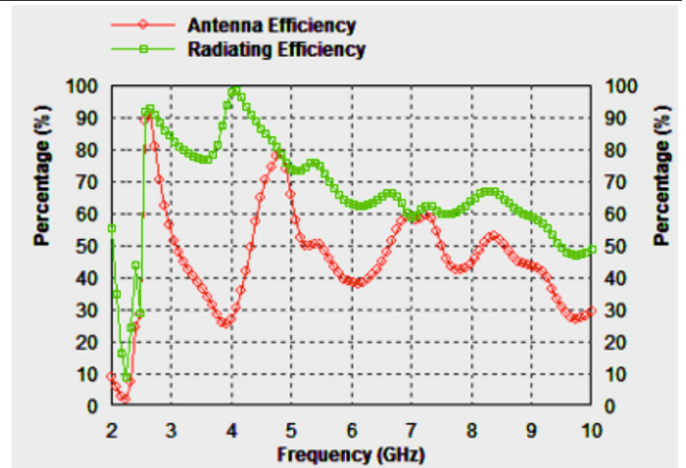


Figure 13 Efficiency Vs Frequency

The radiating efficiency and antenna efficiency is depicted in fig 13, antenna efficiency achieved up to 90% and radiating efficiency up to 98%.

Table 1 Validation of all proposed antenna

Design	Theoretical Design	Design with single U-Slot	Proposed antenna with single U-Slot and via hole technique	Proposed antenna with single U-Slot square slot with via hole technique	Design with folded U-Slot square slot and shorting via hole technique
frequency	2.8GHz, 5.4GHz	4.2GHz, 7GHz	4.8GHz, 7GHz	4.8GHz, 7GHz	2.5GHz, 4.8GHz and 7GHz
Return losses	-14dB, -14.2dB,	-11.5dB, -11.5dB,	-10.5dB, -33dB	-11dB, -32dB	-17.5dB, -28dB, -27dB

From this validation concluded that Design with folded U-Slot square slot and shorting via hole technique is gives three frequency at which return loss is less compare rest of geometry

#### IV. CONCLUSION

A multi frequency Folded U-Slot microstrip antenna is design and validated in this paper. The design antenna consists of folded u-slot, square slot, with via hole technique, the results of all technique is shown in each section step wise, this technique enhance return losses for all three frequency 2.5GHz, 4.8GHz and 7GHz return losses are -17.5dB, -28dB, -27dB, respectively and gives compactness of 50% at frequency of 2.5GHz, The resonant frequencies of the proposed antenna are determined by transmission line model. The physical size parameters of proposed design is calculated using transmission line model, the multi frequency capability is obtained by adjusting the parameters of the proposed structure. Validation of all antennas shown in table-1. The proposed antenna operates at 2.5, 4.8, and 7 GHz, respectively. The multi frequency capability useful in applications of WLAN, Bluetooth, applicable in S-Band and C-Band, Wi-Max, and satellite communication.

#### REFERENCES

- [1]. M. S. Majedi and A. R. Attari, "A compact and broadband metamaterial-inspired antenna," IEEE Antennas Wireless Propag. Lett., vol. 12, pp. 345–348, 2013.
- [2]. B. C. Park and J. H. Lee, "Omnidirectional circularly polarized antenna utilizing zeroth-order resonance of epsilon negative transmission line," IEEE Trans. Antennas Propag., vol. 59, no. 7, pp. 2717–2720, Jul. 2011.
- [3]. C.-J. Lee, H. Wei, A. Gummalla, and M. Achour, "Small antenna based on CRLH structures: Concept, design, application," IEEE Antennas Propag. Mag., vol. 53, no. 2, pp. 10–25, Apr. 2011.
- [4]. H.-X. Xu, G.-M. Wang, M.-Q. Qi, C.-X. Zhang, J.-G. Liang, J.-Q. Gong, and Y.-C. Zhou, "Analysis and design of two-dimensional resonant type composite right/left-handed transmission lines with compact gain enhanced resonant antennas," IEEE Trans. Antennas Propag., vol. 61, no. 2, pp. 735–747, Feb. 2013.
- [5]. T. Jang, J. Choi, and S. Lim, "Compact coplanar waveguide (CPW)-fed zeroth-order resonant antennas with extended bandwidth and high efficiency on vias single layer," IEEE Trans. Antennas Propag., vol. 59, no. 2, pp. 363–372, Feb. 2011.
- [6]. J. K. Ji, G. H. Kim, and W. M. Seong, "A Compact Multiband Antenna Based on DNG ZOR for Wireless Mobile System," IEEE Antennas Wireless Propag. Lett., vol. 8, pp. 920–923, 2009.
- [7]. A. Lai, K. M. K. H. Leong, and T. Itoh, "Infinite wavelength resonant antennas with

- monopolar radiation pattern based on periodic structures,"IEEE Trans. Antennas Propag., vol. 55, no. 3, pp. 868–876, Mar. 2007.
- [8]. Y. D. Dong, H. Toyao, and T. Itoh, "Compact circularly-polarized patch antenna loaded with metamaterial structures," IEEE Trans. Antennas Propag., vol. 59, no. 11, pp. 4329–4333, Nov. 2011.
- [9]. B. C. Park and J. H. Lee, "Dual-band omnidirectional circularly polarized antenna using zeroth- and first-order modes," IEEE Antennas Wireless Propag. Lett., vol. 11, pp. 407–410, 2012.
- [10]. H. E. A. El-Raouf and S. S. Zaheer, "Design of small planar antennas based on double-layered CRLH metamaterials," Microw. Opt. Technol. Lett., vol. 54, no. 10, pp. 2224–2227, 2012.
- [11]. A. De Sabata and L. Matekovits, "Unit cell geometry in strip-line technology featuring sequential bandgaps between every two consecutive modes," IEEE Antennas Wireless Propag. Lett., vol. 11, pp. 97–100, 2012.
- [12]. A. De Sabata and L. Matekovits, "Reduced complexity biasing solution for switched parallel plate waveguide with embedded active metamaterial layer," J. Electromagn. Waves Appl., vol. 26, pp. 1828–1836, 2012.
- [13]. H.-X. Xu, G.-M. Wang, M.-Q. Qi, and H.-Y. "Ultra-small singlenegative electric metamaterials for electromagnetic coupling reduction of microstrip antenna array," Opt. Express, vol. 20, no. 20, pp. 21968–21976, 2012.